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GB A 2076979	GB 1517231
GB A 2027914	EP A 0124976
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(58) Field of search
G1W

(54) Counting by weighing

(57) The number, or value, of a quantity of similar items, eg bank notes or coins, is determined by a weighing technique in which a measure of the unit weight of the items is determined, a batch of the items is then placed on a weighing device (2) and a determination is made by a microprocessor (7), of whether the batch can be counted to an acceptable degree of accuracy. If accuracy is acceptable, the new sample size is used to redetermine the unit weight and the device is recalibrated on this basis. Further items may be added in successive batches with the device recalibrating at each stage provided the required degree of accuracy is met. If at any stage too many items are added to permit counting to the required degree of accuracy, the device will not recalibrate and will indicate this state to the user, who should remove some items until recalibration is possible.

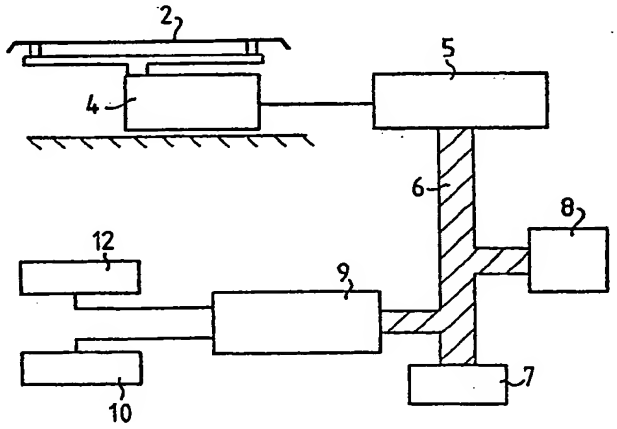

Fig.3

GB 2 155 190 A

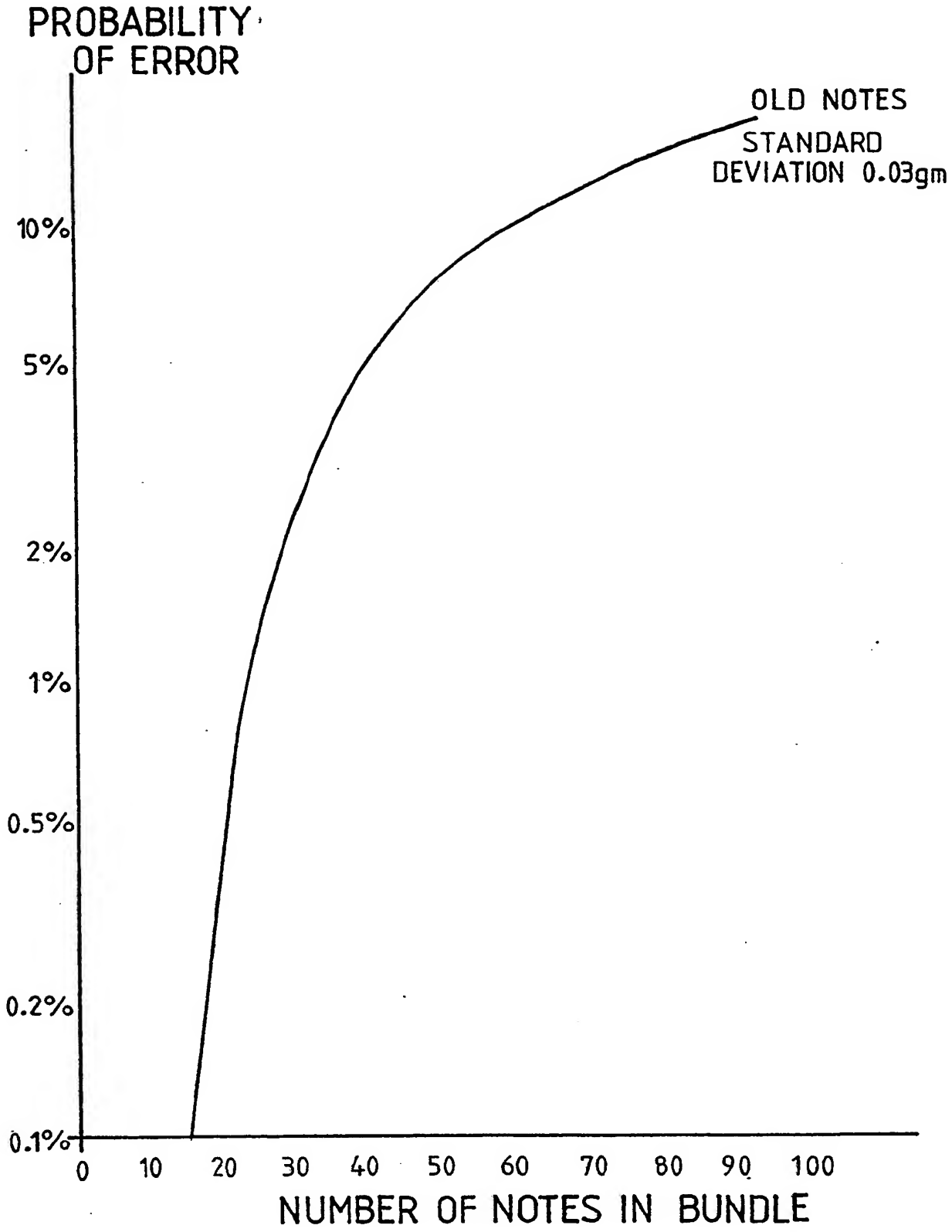

Fig.1

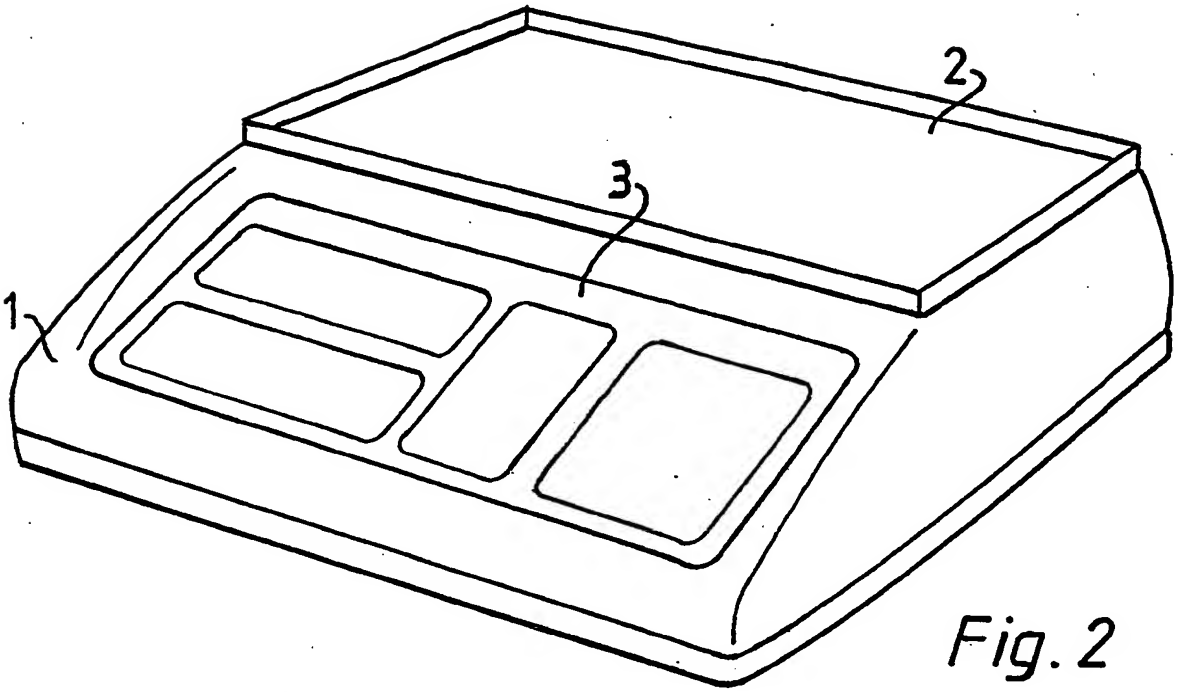

Fig. 2

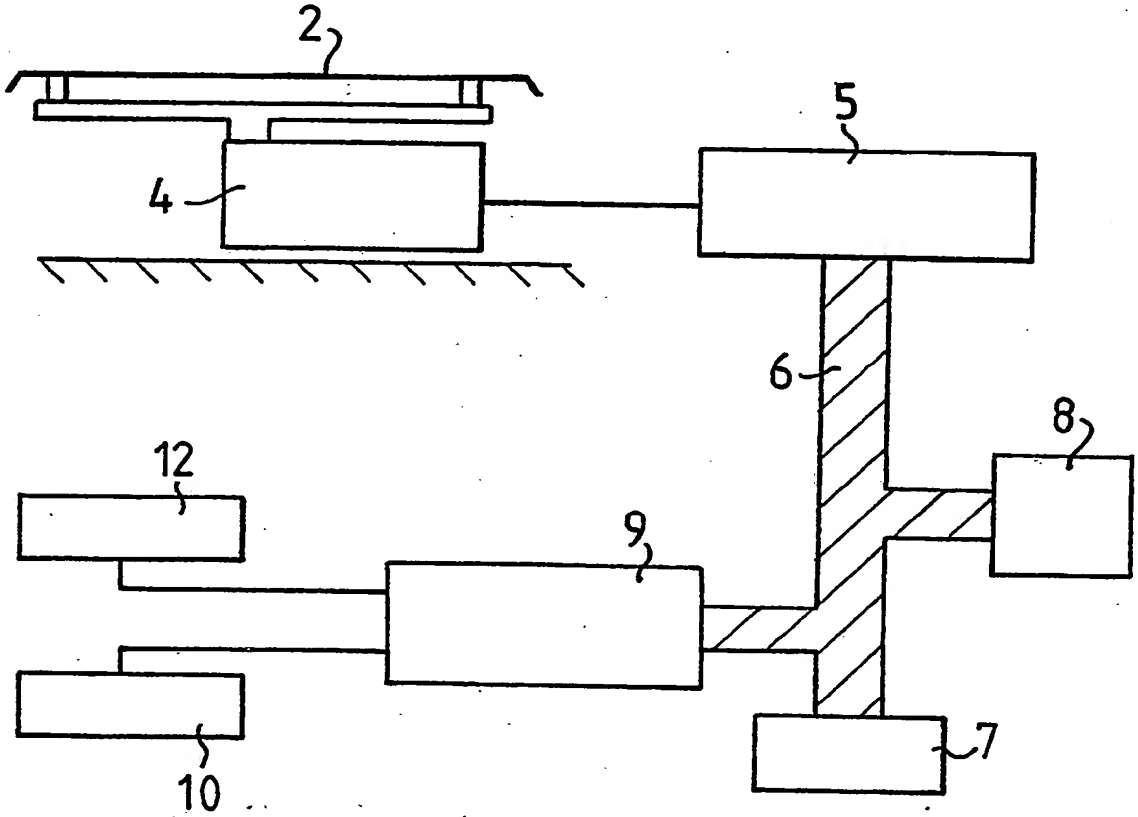

Fig. 3

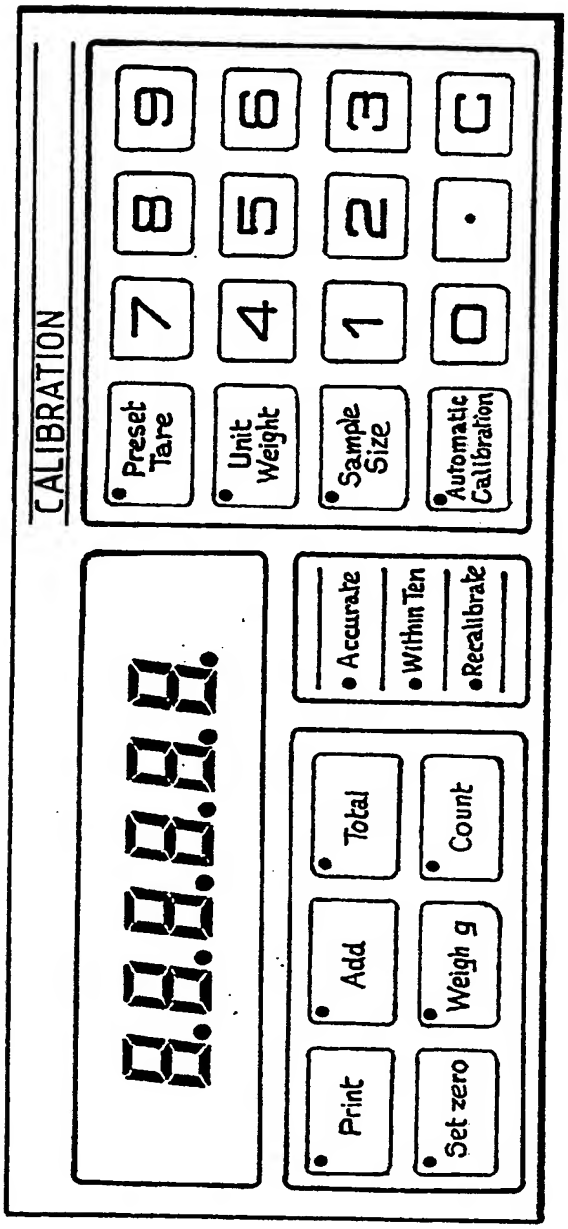

Fig.4

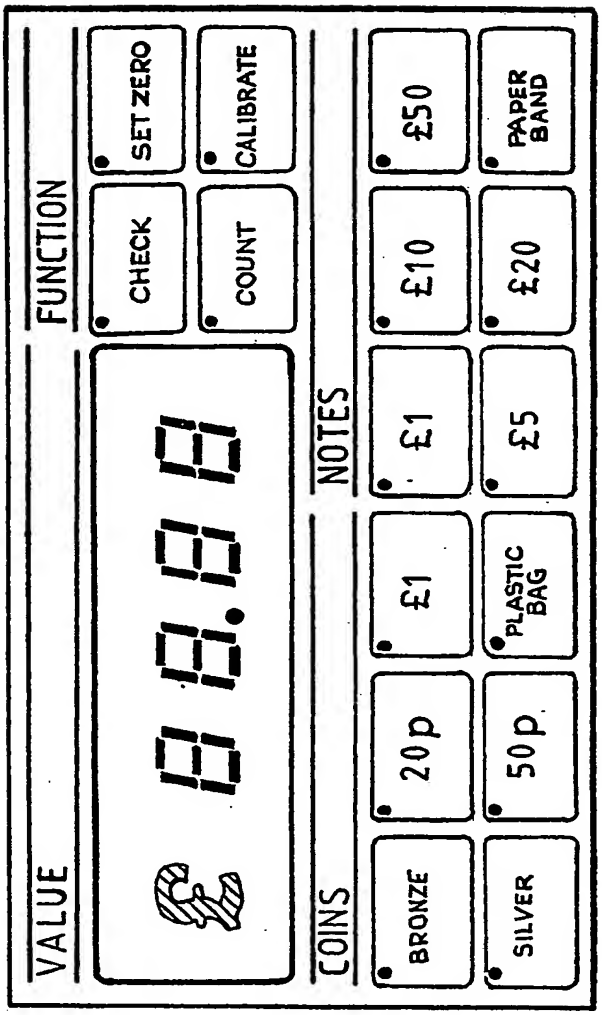

Fig.5

SPECIFICATION

Weighing device and method of operation

Field of the invention

This invention relates to weighing devices, and particularly to electronic weighing devices for determining the number of items placed on the device, or their value. The invention also relates to a method of determining the number of items placed on a weighing device, or their value.

Background to the invention

The use of electronic scales to determine the number of items being weighed is well known. The basic operation relies on an expected unit weight being previously entered to the scale by means of a calibration routine, and hence the number of items is calculated by dividing the total weight by the unit weight. The resulting number of items may thus be displayed.

For money weighing applications, the technique used is the same, but after the count has been determined the actual value of the money is computed and displayed. The following considerations apply whether the count is displayed directly, or some other amount derived from the count is displayed instead.

Limitations to the accuracy of this technique arise from several possible sources of error, and are not normally taken adequately into consideration in presently available equipment. The calibration unit weight must itself be determined by a weighing operation, and this will be limited by the accuracy of the scale used. The actual weighing of the unknown quantity is similarly limited by the accuracy of the scale used. The combination of these effects can lead to significant inaccuracies of indicated count, of which the operator will normally be unaware.

In order to reduce error in the unit weight determination, the calibration weighing is often performed with a large number of items. The relative importance of scale accuracy is thus reduced, but the process is both tedious and time consuming, and may introduce further, human errors in the hand counting process.

Consider items with unit weight W, which has been determined by weighing a sample S such items, the possible error in the weighing operation being e_s. The fractional error in the unit weight thus determined is E_s, given by $E_s = e_s/(SxW)$

Similarly, when an unknown number of items N are weighed, with error e_n, the fractional error in weight, E_n, is given by $R_n = e_n/(NxW)$

If these weighings are used to estimate the number N, then the possible fractional error in N is $(E_s + E_n)$. Hence the possible error ΔN is given by :

$$\Delta N = N (E_s + E_n).$$

By way of illustration, consider as an example items with a unit weight of 4 gms. Calibration is achieved by weighing 10 items, and then 200 items (the unknown quantity) are weighed. If the possible scale error for both weighings is 0.5 gm, then the possible error in the calculated number of items, ΔN is 2.625. Thus, in practical terms:

Number of items, $N = 200 \pm 3$

It can be readily be shown from the above considerations that improved accuracy can be achieved if the calibration takes place with a larger sample size. Also, for any particular set of circumstances, there will be a maximum value for which N will be accurate,

ie $\Delta N < 0.5$

For a particular design of scale, the possible error associated with measuring weight may be determined as a function of that weight by a combination of measurements and calculations. This may thus be represented as an empirical formula or set of tabulated data or in some other useful form. Thus when computing the count the possible error can also be calculated, and may be indicated.

Summary of the invention

According to one aspect the invention provides a weighing device for determining the number of a quantity of similar items placed on the device, or their value, the device comprising means for determining a measure of the weight per unit item, determining means responsive to a batch of items placed on the device to determine whether the batch can be counted to an acceptable degree of accuracy, recalibrating means for recalibrating the device for the said batch if the latter can be counted to said acceptable degree of accuracy so as to obtain a recalibrated measure of the weight per unit item, and means for using the recalibrated value as a basis for determining the total number of items, or their value, placed on the device after a further batch of items has been added to the first-mentioned batch.

According to another aspect the invention provides a method of determining the number of a quantity of similar items placed on a weighing device, or their value, comprising determining a measure of the weight per unit item, placing a batch of items on the device and determining whether the batch can be counted to an acceptable degree of accuracy, if the batch conforms to said acceptable degree of accuracy recalibrating the device for the said batch to give a recalibrated measure of the weight per unit item, adding a further batch of items to the device and using the recalibrated value as a basis for determining the total number of items, or their value, placed on the device.

In use, after initial calibration of the weight per unit item, a batch of items to be weighed is placed on the device. If the total number of items on the device can be determined to within the acceptable degree of accuracy, and if the number is greater than the previous calibration sample size, then the scale recalibrates using the new number for calibration, giving a more accurate estimate of unit weight. Further items may then be added to the device in successive batches, with the device recalibrating at each stage provided the required degree of accuracy is met. If at any stage too many items are added in a batch to permit recounting to the required degree of accuracy, the device will not recalibrate and will preferably indicate this state to the user. The user should then remove some of the items until recalibration is possible. The process of adding batches may then be continued.

An initial measure of the weight per unit item may be determined by sensing the weight of a counted batch of items placed on the device, the number in the counted batch being predetermined or entered into the device to enable said weight per unit item to be derived. Alternatively, a measure of the weight per unit item may be obtained from information input to the device, or from stored values of the unit weight for different types or denominations of items, the type or denomination of item being entered into the device, eg via suitable input means such as keys.

Counting, accuracy determination and recalibration are conveniently effected by a microprocessor programmed with a suitable algorithm to determine the unknown number of items, N, and the possible error in the calculated number if items, ΔN, as indicated above.

Assuming there is no variation in the weights of the individual items, absolute accuracy can be obtained by recalibrating the device only when the possible error in the calculated number of items, ΔN, is less than 0.5.

In practice, however, there may well be variation in the individual weights of the items, and such variations can be taken into account, although commonly the limitations due to scale weighing errors will be significantly more important than possible errors due to weight variations of mass produced components.

Where the items to be counted can be specified, either by a part number (eg in a stores situation) or by type (eg when counting coins or bank notes) then the variation of weights can be measured, and by imposing further constraints to the accuracy determining algorithm, the probability of error in the final computed count may be reduced to any desired degree.

Consider a total population of like items, which has mean weight M, and standard deviation σ. When a sample of N items is taken, the mean weight of the sample will be M', and if the resulting difference of total weight from the expected total weight is greater than half of the mean weight, then a counting error will result

$$\text{ie if } (M'-M)\,N > M/2$$

The probability of this event can be estimated using standard statistical tables.

By way of illustration, consider the problem of counting used £1 notes using a money weigher. Typically values for mean weight and standard deviation are:

$$M = 0.74\ \text{gm}$$
$$\sigma = 0.03\ \text{gm}$$

Figure 1 shows the statistical probability of error for different quantities of notes. For example, for 100 notes the probability of error will be approximately 20%, whereas if the number of notes is limited to 25, this is reduced to around 1%.

In order to limit errors due to variation of weight, a convenient technique is to determine from statistical information for a given item the maximum number, I, by which the sample size may be increased at each stage, provided also that the other conditions relating to scale accuracy have also been satisfied,

$$\text{ie } N - S < I$$

The value of I may thus be selected to suit the standard deviation of the items, and desired accuracy of the computed count, with the value of I being stored in the device and displayed to act as a guide to the user who should add no more thar the specified number of items in each additional batch.

Operation of a counting scale using the recalibration feature of the invention is greatly improved as compared with conventional equipment. First, the initial calibration (if done by weighing rather than using stored or input data) need not be very accurate, enabling rapid operation, and only requiring a small number of items to be hand counted initially. When further items are added, and provided that accuracy is maintained, the scale will automatically recalibrate with the larger number. This may be continued with the

further addition of samples, so that the total number of items is determined with the required degree of accuracy.

The invention finds application in general purpose counting and is also particularly well suited to money counting applications.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a graph showing the statistical probability of error, due to weight variation, of the number of old £1 notes determined by weighing a bundle;

Figure 2 is a perspective view of a weighing device in accordance with the invention;

Figure 3 is a schematic representation of the device of Figure 2;

Figure 4 illustrates one version of keyboard and display for the device of Figures 2 and 3, suitable for use in general purpose counting applications; and

Figure 5 is a view similar to Figure 4 illustrating an alternative version of keyboard and display for the device of Figures 2 and 3, suitable for use in weighing money.

Detailed description of the drawings

The weighing device illustrated in Figures 2 and 3 is in the form of an integrated, stand alone scale comprising a casing 1 on which is mounted a weighing pan 2. The frame of the casing has a panel 3 with a keyboard and display.

Weighing is carried out on the pan 2, and a single point load cell 4 is used to convert weight to an analogue electrical signal. An analogue to digital converter 5 then converts the weight information to digital form and is interfaced through a microprocessor bus 6 to a microprocessor 7. A user interface 9 allows the operator to key instructions from a keyboard 10, and digital data on a display 12 may also be accessed by the microprocessor 7. The microprocessor control program 8 governs the way the unit operates.

The weighing device described above may form the basis of a number of different embodiments intended for different uses, with the operator interfaces (keyboard 10 and display 12) and modes of operation (as determined by pre-programming of microprocessor 7) varied as appropriate.

Figures 4 and 5 illustrate two alternative keyboard and display arrangements for two such embodiments, which will now be described.

1. Example of general purpose parts counter

Figure 4 shows an enlarged view of the keyboard and display of the unit for this first embodiment.

The illustrated keyboard includes digit keys together with a number of function keys and indicators, as follows:

Set Zero This key allows zero weight to be defined and if necessary any container weight to be tared.

Weight Selects normal weight function. The unit behaves as a simple digital scale with weight displayed.

Count Selects count mode and causes computed count to be displayed.

Preset Tare This allows a numerical value of preset tare to be entered via the decimal keys.

Unit Weight This allows a predetermined unit weight to be entered via the decimal keys, and hence used with net weight for the computation of count.

Sample Size This allows a predetermined sample size to be entered, hence to compute unit weight from measured net weight and sample size.

Automatic calibration May be used to enable or disable the automatic calibration feature.

Print Causes currently displayed data to be sent to a line printer (if connected) to provide permanent printed records.

Add Adds currently displayed count into a total register.

Total Enables the total register to be accessed.

Accuracy Indicators Three indicators showing the computed accuracy of the displayed count. For convenience these are divided into three bands:

- Accurate
- Within ten
- Recalibrate (worse than 10)

In use, typical operation to count an unknown number of items would be as follows:

a) Hand count 10 items and place on weight pan.

b) Enter Sample Size of 10 using keyboard. The scale is now calibrated with sample size of 10, and accuracy indicator shows 'accurate'.

c) Enable automatic calibration feature.

d) Add more items. Display shows count of 20, and 'accurate'. Scale automatically re-calibrates with sample size of 20.

e) Add remainder of items. Display shows 200, and 'within ten'. Scale does not recalibrate.

f) Remove some items. Display shows 100 and 'accurate'. Scale automatically re-calibrates.

g) Add remainder of items. Display shown 202 and 'accurate'. Scale automatically re-calibrates.

It will be noted from this sequence that only 10 items have been hand counted, and a completely accurate count of all 202 items has been achieved very readily. By conventional techniques, approximately 50-100 items would have needed to be pre-counted to be completely accurate, and the operator would have been unaware of possible errors.

2. Example of money weighing

Figure 5 shows an enlarged view of the keyboard and display of the unit for this second embodiment.

Note that for operator convenience, the computed value of the coins or notes is displayed, rather than count. Otherwise the operating principles are identical to those of the previous embodiment.

The illustrated keyboard includes function keys as follows:

Bronze/Silver/20p/50p/£1 Allow the denomination of selected coins to be entered by single key operation. Calibration of unit weight is then automatically set to the known values of the particular denomination. For mixed bronze and silver, the smallest denomination is assumed (ie 1p or 5p) and because of the weight relationship of the currency the computed value will be correct.

£1/£5/£10/£20/£50 Allow the denomination of selected notes to be entered by single key operation. Calibration of appropriate unit weight occurs automatically, as above.

Bag Automatically enters a tare value for a standard coin bag.

Band Automatically enters a tare value for a standard note band.

Check Selects mode to check contents of standard bags or bundles using known calibration unit weight for the denomination selected.

Count Selects mode which enables an accurate count to be made using the automatic calibration feature - see below.

Set Zero This allows the scale zero weight to be defined, and any non-standard bag or band or other container to be tared.

Calibrate To allow for slight variations of average notes (eg for badly soiled notes, humid conditions when notes absorb moisture and increase in weight, or badly worn coins) the scale can be recalibrated for the current sample.

Typical operation to count an unknown number of £1 notes might be as follows:

a) Select denomination of £1 notes. Data for £1 notes is then used for unit weight, and maximum incremental number (eg set as 25 for 99% accuracy).

b) Place small number of notes on weight pan. Display shows £10 and scale automatically re-calibrates to current sample.

c) Put further notes onto weight pan (total say approx 40). Displays shown message 'SUB' prompting removal of some notes since accuracy has been lost.

d) Remove some notes. Display shown £30 and scale automatically re-calibrates.

e) Add remainder of notes. Display shows £50 and scale automatically re-calibrates.

Note that no items have actually had to be counted because the standard calibration for £1 notes gives the correct small initial count. Also, the mean weight of the sample of notes might have been different to the standard calibration stored within the unit, so that a simple 'Check' of the weight of the bundle could have shown £51 for example. The technique means that an accurate count can be achieved very quickly.

CLAIMS

1. A weighing device for determining the number of a quantity of similar items placed on the device, or their value, the device comprising means for determining a measure of the weight per unit item, determining means responsive to a batch of items placed on the device to determine whether the batch can be counted to an acceptable degree of accuracy, recalibrating means for recalibrating the device for the said batch if the latter can be counted to said acceptable degree of accuracy so as to obtain a recalibrated measure of the weight per unit item, and means for using the recalibrated value as a basis for determining the total number of items, or their value, placed on the device after a further batch of items has been added to the first-mentioned batch.

2. A device according to claim 1, wherein the determining means and recalibrating means are constituted by a microprocessor programmed to determine the unknown number of items and the possible error in the calculated number of items.

3. A device according to claim 1, wherein the microprocessor additionally constitutes the means for determining a measure of the weight per unit item.

4. A device according to claim 2 or 3, wherein the microprocessor has associated therewith display means and input means by which a user can input information to the device.

5. A device according to claim 1, 2, 3 or 4, wherein the device has stored therein data on the average unit weight of one or more different types of item.

6. A device according to any one of the claims 1 to 5, wherein the device has stored therein data on the likely variation in unit weight of one or more different types of item.

7. A device according to any one of claims 1 to 6, wherein the device has stored therein data on the maximum number of items to be added in a batch for one or more different types of item, with means for displaying the values of the maximum batch size.

8. A device according to claim 5, 6 or 7, having stored therein data relating to more than one different type of item, and additionally comprising input means to input to the device information as to which type of item is to be weighed.

9. A device according to any one of the preceding claims, additionally comprising input means whereby a user can input to the device information concerning the unit weight of a type of item.

10. A device according to any one of the preceding claims, additionally comprising input means whereby a user can input to the device information concerning the number of items in a sample of known size and initiate calculation by the device of the unit weight.

11. A device according to any one of the preceding claims, comprising a weighing pan with associated load cell.

12. A device according to any one of the preceding claims for counting money, wherein the counting and recalibrating means comprise a microprocessor with stored data on the unit weights and likely variation therein of different denominations of coins and bank notes, the device including a keyboard for inputting to the device the denomination of money to be counted.

13. A device according to claim 12, including display means for displaying the value of money counted.

14. A device according to any one of the preceding claims, including means for indicating whether a batch can be counted to said acceptable degree of accuracy.

15. A weighing device substantially as herein described with reference to, and as shown in, Figures 2, 3 and 4 of the accompanying drawings.

16. A weighing device substantially as herein described with reference to, and as shown in, Figures 2, 3 and 5 of the accompanying drawings.

17. A method of determining the number of a quantity of similar items placed on a weighing device, or their value, comprising determining a measure of the weight per unit item, placing a batch of items on the device and determining whether the batch can be counted to an acceptable degree of accuracy, if the batch conforms to said acceptable degree of accuracy recalibrating the device for the said batch to give a recalibrated measure of the weight per unit item, adding a further batch of items to the device and using the recalibrated value as a basis for determining the total number of items, or their value, placed on the device.

18. A method according to claim 17, including placing one or more further successive batches of items on the device.

19. A method according to claim 17 or 18, wherein the measure of the unit weight is determined by weighing a sample of known size.

20. A method according to claim 17 or 18, wherein the measure of the unit weight is determined from information input to the weighing device.

21. A method according to claim 17 or 18, wherein the measure of the unit weight is determined from data stored in the weighing device.

22. A method according to any one of claims 17 to 21, wherein the counting, determining and recalibrating are effected by a microprocessor.

23. A method according to claim 22, wherein the determining step takes into account stored data on the likely variation in unit weight of the type of item being weighed.

24. A method according to any one of claims 17 to 23, additionally comprising inputting to the weighing device information as to which type of item is to be weighed prior to the weighing operation.

25. A method according to any one of claims 17 to 24, wherein the value of bank notes being weighed is determined and displayed.

26. A method of determining the number of a quantity of similar items placed on a weighing device, or their value, substantially as herein described with reference to Figures 2, 3 and 4 of the accompanying drawings.

27. A method of determining the value of a quantity of similar bank notes or coins placed on a weighing device, substantially as herein described with reference to Figures 2, 3 and 5 of the accompanying drawings.

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